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TRENDS IN NITRATE-NITROGEN, NITRITE-NITROGEN AND PHOSPHORUS CONCENTRATION IN EBONYI RIVER, NIGERIA

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ABSTRACT
A baseline study of the limnological integrity of Ebonyi River, a tropical lotic system in south-eastern Nigeria was conducted between September 2006 and February 2008 to assess its potential in enhancing fisheries production for the benefit of the rural poor, who depend on the resources of the river for survival. The parameters measured were nitrate-nitrogen, nitrite-nitrogen and phosphate-phosphorus. Results show that nitrate varied between 40.43mg/L in September 2006 and 1.73mg/L in December 2007, Showing significant difference ($P<0.01$) among months. The values recorded for nitrites varied between 0.2mg/L in September 2006 and 0.4mg/L in February 2008, showing significant ($P<0.01$) variation among months. Values recorded for phosphorus was highest (0.05mg/L) in the month of October 2006 while the least mean value (0.32mg/L) was recorded in the month of May 2007 and showed significant ($p<0.01$) variation in monthly means. It was concluded that the values of the measured parameters falls within tolerable range for enhanced fisheries development in the area.

KEYWORDS: Limnology, Tropical, River, Monthly, Mean, Variation

INTRODUCTION

Less than 0.01% of the Earth's total water resources occur in liquid form covering approximately 3% of the land surface (Revenga and Kura, 2003). Extreme variability in the spatial and temporal distribution of this small amount of water, together with the large geomorphologic variability, has resulted in a variety of water bodies – from ephemeral pools to large lakes and mighty rivers. A significantly large proportion of the Earth's biodiversity representing nearly all kinds of organisms – from microorganisms to mammals – inhabits inland waters (Revenga and Kura, 2003).

The purpose of environmental assessment and management is ultimately the maintenance of biological integrity. Fish needs certain optimum conditions for feeding, breeding, respirations, growth and movement.

Recent evidence indicates that some sedimentary rocks contain large amounts of fixed Nitrogen, and so weathering may provide significant amounts of nitrate to running waters in some circumstances (Holloway *et al.*, 1998, Thompson *et al.*, 2001, Williard *et al.*, 2005). Spatial variation in stream water nitrate concentrations is influenced by nitrification in upland soils, which affects the extent to which catchments retain or export nitrate via stream flow (Likens and Bormann 1995, Bernhardt *et al.*, 2005).

Principal anthropogenic inputs of Nitrogen to streams include agricultural fertilizers, atmospheric deposition, N-fixing crops, and human and animal wastes (Boyer *et al.*, 2002). Nitrogen inputs often vary seasonally due to the effects of the growing season and hydrology. Due to uptake of N by terrestrial vegetation, stream water concentrations tend to be lower during the growing season and higher during the dormant season (Vitousek *et al.*, 1975). Although some fertilizer is assimilated by crops, when applied at high levels, substantial amounts of N leach into surface and groundwater, resulting in increases in river nitrate concentrations (Heathwaite *et al.*, 1996, Gachter *et al.*, 2004)

Meybeck (1982) reported that major forms of nitrogen found in natural waters appear as dissolved inorganic nitrogen, nitrate (NO3-), nitrite (NO2-), ammonium (NH_4+), dissolved organic Nitrogen. All these added together are referred to as total dissolved nitrogen. Another form of Nitrogen in water is particulate organic nitrogen. The entire forms of N summed up are known as total nitrogen.

Major forms of phosphorus found in natural waters are present as dissolved inorganic phosphorus (PO43-), orthophosphate or soluble reactive phosphorus). This is also known as total dissolved phosphorus. It is also present as dissolved organic phosphorus and particulate organic phosphorus. These are referred to as total organic phosphorus. A combination of total dissolved phosphorus and total organic phosphorus is known as total phosphorus (Meybeck, 1982).

Allan and Castillo (2007) reported that nitrogen and phosphorus are the major nutrients that have been found to influence rates of primary production and the activity of heterotrophic microbes. Research has shown that benthic algal productivity can be limited by either N or P singly, be co-limited by both, or not be nutrient limited (Allan and Castillo, 2007). Sources and supplies of N and P vary considerably with geology, soils, climate, and vegetation, and their concentrations often are substantially elevated owing to anthropogenic inputs.

Phosphorus in waters is present in several soluble and particulate forms including organically bound phosphorus, inorganic polyphosphates and inorganic orthophosphates (Lind, 1979). Adeniji (1983) regarded phosphorus as a biologically active element which cycles through many states in the aquatic ecosystem, and its concentration in any one state depends on the degree of metabolic synthesis or decomposition occurring in the aquatic system. Similarly, Cole (1983) observed that phosphorus is the element most likely to cause a stimulation of plant production and is thus often measured in relation to excessive production and problems of eutrophication.

Phosphorus dynamics in streams is influenced by physical, chemical and biological process. The principal biological process are autotrophic and heterotrophic uptake of dissolved P and its assimilation into cellular constituents , transfer of organic phosphorus through the food chain and its eventual release and mineralization by excretion and the decomposition of egested material. Algae and microbes in biofilms likely obtain the majority of their P from the water column, but rooted macrophytes and benthic algae can remove P from the sediments as well. Phosphorus may be excreted or released following cell lysis directly as dissolved inorganic P, which subsequently is mineralized to orthophosphate by bacterial activity. The decomposition of organic matter including feces, dead organisms and leaf litter also releases P into the water column and sediment pore water (Mainstone and Parr 2002).

Ebonyi River is a freshwater river system which opens into Cross River and subsequently the Atlantic Ocean. Thus ecological changes within the river are of inter-regional concern. The river is bounded by many communities in Ebonyi State. At the moment there seems to be no published information on its physicochemical properties.

This study is considered important because of the multiple uses of Ebonyi River. Apart from its relevance as source of fish production it serves the people as source of portable water supplied by the State Water Corporation after purification. It also provides facilities for wildlife, transportation and vegetable irrigation farms for the people. In view of the multipurpose use of the river, impacts of schemes that change the form and function of the river and hydrograph on fish and fisheries can be anticipated in project planning. Unfortunately in spite of the recognized importance of the river and the various activities taking place in and around it, little or no detailed scientific information on the river is available.

MATERIALS AND METHODS

Area of Study

The area of study is Ebonyi River which is a freshwater system that has its source from lower Benue River and opens into Cross River, but transverses the old Abakaliki Zone of Ebonyi State, Nigeria. Abakaliki is situated between 06^0 19.370\` North latitudes and $008^0$ 07.692\` East longitudes. There are two distinct seasons within the zone; a wet season which starts from April to August and the dry season which starts from September to March. The research work covered the period from September 2006 to February 2008.

Sampling Locations: Sampling locations were chosen after preliminary surveys of the river based on such factors as representation of upstream, midstream and downstream, volume of water, depth, activities taking place in and around the river and accessibility. Four sampling locations were marked at intervals of 3.5 to 8km (Figure 1).

Location 1 is in Ebonyi Local Government area. The area serves the locals as source of water for domestic use as well as site for dry season irrigation farming for vegetables and fishing amongst other uses.

Location 2 is about 1.5km from the Faculty of Agriculture and Natural Resources Management campus of the State University. The site is prominent because, the pumping station of the State water corporation is located there. This mini dam at this site ensures availability of large volume of water all year round in the station allowing for fishing activities, irrigation vegetable farming and other domestic uses

Location 3 is located at Onuebonyi, 500metres from Ebonyi State Fertilizer blending Industry. It is also a site for domestic water supply to the rural dwellers within the vicinity. Fishing and small scale irrigation activities also goes on around the station.

Location 4 is located at Echara in Ikwo local Government area. This is the major source of water supply for the rural dwellers of the area. Artisanal fishing and river-side irrigation vegetable farming are among the notable activities taking place in the station.

All analysis was done using the standard methods described in APHA (1999) and Lind (1979). Water samples was collected fortnightly from the chosen stations (1, 2, 3 and 4) using sampling bottles.

The analysis of phosphate-phosphorus was by colorimetric method using HANNA analytical kit.

RESULTS

The monthly mean variation of nitrate-nitrogen in relation to station in Ebonyi River is presented in Table 1, it varied between 40.43mg/L in September 2006 and 1.73mg/L in December 2007, Showing significant difference ($P<0.01$) among months. The means of location 1 and 2 showed no significant ($P>0.05$) from each other but varied significantly ($P<0.01$) from location 3 and 4 whose values are not significantly different from each other.

The result of monthly mean values of Nitrite-Nitrogen in relation to locations is presented in table 2. The values varied between 0.2mg/L in September 2006 and 0.4mg/L in February 2008. It also showed significant ($P<0.01$) variation between seasons while there was interaction in the values of December 2006 and March 2007. Similarly the mean values of December 2007 interacted with those of January and March 2008 Fig. 2 shows the monthly variation of the values of nitrite-nitrogen in relation to stations.

The mean monthly variation of phosphate phosphorus in relation to stations in Ebonyi River showed higher concentration in the months of the end of rainy season, the highest mean value (0.05mg/L) recorded in the study period was in the month of October 2006 while the least mean value (0.32mg/L) was recorded in the month of May 2007. (Table 3) variation in monthly mean values was significant ($P<0.01$) different months. Location 1 and 4 were not significantly different ($P>0.05$) from each other but varied significantly ($P<0.01$) from locations 2 and 3 which are also significantly different ($P<0.01$) other locations.

DISCUSSION

Nitrate nitrogen was found to exhibit the pronounced seasonal variation of all other chemical parameters measured. The mean values recorded in rainy season were higher than those recorded for other months. The reason for this high concentration may be due to excessive influx of nutrients from farm lands where fertilizer is used to boost crop production particularly around the river environment as well as input through runoff into the river. Nwoko (1991) had suggested that nitrate nitrogen could get into the water through various sources such as cattle dung, fertilizer run-off and leaching of leguminous farms. The decrease in concentration level of the nitrate nitrogen in other months may be due to heterotrophic uptake by micro-organisms, sediment adsorption and complete loss of some aquatic macrophytes.

Phosphate phosphorus concentration values were higher in October, and July than in other months. Olsen and Sommerfield (1977) associated phosphate increase with phytoplankton standing crop increase. The recorded values remained stable in most other months. Sandra (2000) reported that phosphorus is the most important and limiting substance controlling organic production. Although the values of phosphate- phosphorus recorded in this study differ from the range 3.8 - 6.30 observed by Beadle (1981) in some productive African rivers and lakes, it agrees with the 20 -51mg/L range recorded in Delimi River by Anadu and Akpan (1986). The sources of phosphorus in the river during the study period may be due to intensive agricultural activities around the river

involving the use of fertilizers and pesticides to produce dry season crops like vegetables and even Maize. Villagers were using water from the river for domestic activities including washing of cloths with detergents which increase phosphate level of the water. It is therefore concluded that the values of the measured parameters falls within tolerable range for enhanced fisheries development in the area if the integrity is enhanced or at least maintained.

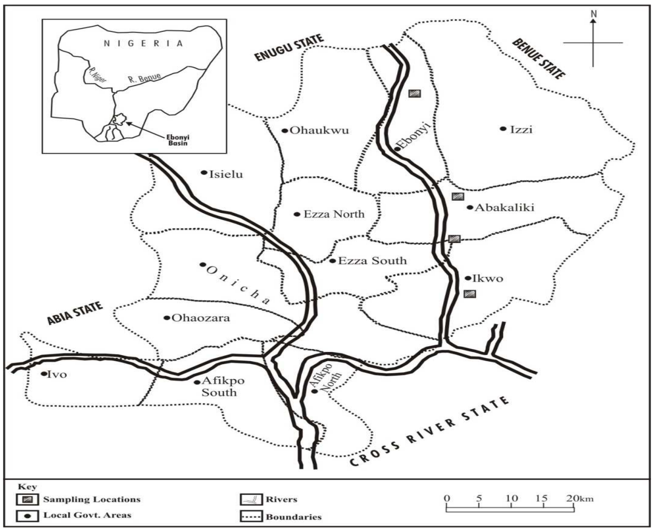

Fig. 1: Map of Ebonyi Basin showing Sampling Locations

Table 1: The Monthly Mean Values of Nitrate Nitrogen Concentrations (mg/L) in Relation to Locations in Ebonyi River

	Locations				
Months	1	2	3	4	**Mean**
September 2006	41.140	40.260	39.810	40.490	40.425^{a}
October 2006	13.405	14.020	14.370	14.515	14.078^{g}
November 2006	6.710	5.985	7.570	5.730	6.499^{i}
December 2006	1.585	1.325	1.435	1.665	1.503^{l}
January 2007	1.895	1.470	1.630	1.815	1.703^{l}
February 2007	1.715	1.485	1.805	2.015	1.755^{l}
March 2007	1.660	1.475	1.890	1.895	1.730^{l}
April 2007	20.605	21.630	22.610	23.625	22.117^{f}
May 2007	28.895	28.985	29.640	29.755	29.319^{e}
June 2007	33.590	35.145	35.605	36.205	35.136^{d}
July, 2007	36.110	37.060	37.045	37.340	36.889^{c}
August 2007	36.135	36.270	36. 715	37.530	36.663^{c}
September 2007	37.980	38.225	39.000	39.570	38.694^{b}
October 2007	12.580	12.060	12.830	12.735	12.551^{h}
November 2007	3.425	3.535	4.670	3.480	3.777^{j}
December 2007	1.610	1.655	1.965	1.670	1.725^{l}
January 2008	2.005	2.000	2.035	2.010	2.012^{k}
February 2008	2.015	2.015	2.045	2.025	2.025^{k}
Mean	15.726^{b}	15.811^{b}	16.259^{a}	16.337^{a}	

F- LSD $_{(p< 0.05)}$: Locations = 0.3029**; Months = 0.6426**; Locations x Months = NS

Levels of significance: ** = p<0.01 and NS = non significant,
Means followed by the same latter(s) are not significantly different

Table 2: The Monthly Mean values of Nitrite Nitrogen Concentrations (mg/L) in Relation to Locations in Ebonyi River

	Locations				
Months	1	2	3	4	**Mean**
September 2006	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
October 2006	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
November 2006	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
December 2006	0.3000	0.3000	0.4000	0.3000	0.3250^{cd}
January 2007	0.4000	0.4000	0.4000	0.4000	0.4000^{a}
February 2007	0.4000	0.4000	0.4000	0.4000	0.4000^{a}
March 2007	0.2000	0.4000	0.4000	0.4000	0.3500^{bc}
April 2007	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
May 2007	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
June 2007	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
July, 2007	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
August 2007	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
September 2007	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
October 2007	0.2000	0.2000	0.2000	0.2000	0.2000^{e}
November 2007	0.2000	0.2000	0.4000	0.4000	0.3000^{d}
December 2007	0.3000	0.4000	0.4000	0.4000	0.3750^{ab}
January 2008	0.4000	0.4000	0.4000	0.4000	0.4000^{a}
February 2008	0.4000	0.4000	0.4000	0.4000	0.4000^{a}
Mean	0.2556^{c}	0.2722^{b}	0.2889^{a}	0.2833^{a}	

F- LSD $_{(p< 0.05)}$: Locations = 0.01566**; Months = 0.03322**; Locations x Months = 0.06645**

Level of significance: ** = p<0.01

Means followed by the same latter(s) are not significantly different

Table 3: The Monthly Mean Values of Phosphate Phosphorus Concentrations (mg/L) in Relation to Locations in Ebonyi River

	Locations				
Months	1	2	3	4	**Mean**
September 2006	0.036000	0.043000	0.043000	0.038000	0.040000[f]
October 2006	0.044000	0.056000	0.056500	0.044500	0.050250[a]
November 2006	0.038000	0.043000	0.041000	0.036000	0.039500[f]
December 2006	0.038000	0.043000	0.043000	0.036000	0.040000[f]
January 2007	0.038000	0.047000	0.045000	0.036000	0.041500[e]
February 2007	0.035000	0.049000	0.048000	0.035000	0.041750[de]
March 2007	0.035000	0.049500	0.048000	0.036000	0.042125[d]
April 2007	0.032000	0.042000	0.042000	0.032000	0.037000[j]
May 2007	0.030000	0.037000	0.032000	0.030500	0.032375[l]
June 2007	0.030000	0.040000	0.040000	0.036000	0.036500[k]
July, 2007	0.038000	0.050000	0.049000	0.044000	0.045250[c]
August 2007	0.035000	0.040000	0.038000	0.038000	0.037750[i]
September 2007	0.035500	0.041500	0.039000	0.038000	0.038500[h]
October 2007	0.044500	0.053000	0.053000	0.043000	0.048375[b]
November 2007	0.038000	0.045000	0.041000	0.035500	0.039875[f]
December 2007	0.038000	0.044000	0.041000	0.034000	0.039250[g]
January 2008	0.037000	0.046000	0.044000	0.031000	0.039500[fg]
February 2008	0.035000	0.049000	0.048000	0.037000	0.042250[d]
Mean	0.036500[c]	0.045444[a]	0.043972[b]	0.036694[c]	

F- LSD $_{(p< 0.05)}$: Locations = 0.000293**; Months = 0.000622**; Locations x Months = 0.001243**

Levels of significance: ** = p<0.01
Means followed by the same latter(s) are not significantly different

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